

Toward a Predictive Model of Arctic Coastal Retreat in a Warming Climate, Beaufort Sea, Alaska

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LONG-TERM GOALS

The long-term goal of this project is to quantify the environmental drivers of rapid coastal erosion in the Arctic, and to begin developing predictive models of future rates of coastal erosion resulting from climate change. Our study is focused on the Beaufort Sea coast within the National Petroleum Reserve – Alaska (NPR-A), approximately halfway between Barrow and Prudhoe Bay. We are focusing our efforts on collecting empirical data that will help us to develop process-based models of coastal change.

OBJECTIVES

Our main scientific objective is to understand and quantify the relative roles of thermal and mechanical (wave) energy in driving coastal erosion in the Arctic. We are combining high-resolution observations of coastline retreat with meteorological and oceanic monitoring programs. Our planned and completed field data collection includes: 1) measurement of bluff substrate properties including ice content, ice-wedge polygon spacing, and the thermal properties of bluff materials; 2) time-lapse photography to observe coastal erosion processes in real-time; 3) establishment of a meteorological monitoring network to summarize the climatic forcings on the system; and 4) monitoring of offshore conditions

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including bathymetry, wave fields, and sea surface temperatures. By synthesizing these field observations and remote sensing observations into process-based numerical models, we anticipate that we will be able to predict future patterns of Arctic landscape change in the face of changing climatic

APPROACH AND WORK PLAN

Our technical approach includes direct observation of coastal erosion using time-lapse photography; collection of relevant field data including coastal bluff composition, wave and sea surface temperature records, and meteorological records; and modeling of relevant thermal and mechanical processes.

The personnel involved in these activities are as follows: Analyses of time-lapse photography and meteorological records is being undertaken by Dr. Wobus. Sea ice analyses and wave modeling have been conducted Dr. Overeem with contributions from undergraduate student Cori Holmes. Masters student Nora Matell developed thermal models of lake erosion, and compiled remote sensing datasets from the NPR-A. Numerical models and data mining code have been developed by Drs. Anderson, Wobus, Overeem collaboratively. USGS scientists Clow, Urban and Jones assisted with retrieval of sensors during the 2008-2011 summer seasons. Wave sensors were built by collaborator Tim Stanton at the Naval Postgraduate School in Monterey, and were deployed during the summer field season in 2009, and again in late summer 2010. Higher resolution time-lapse cameras were deployed in collaboration with the Extreme Ice Survey in summer 2010. Graduate student Katy Barnhart was employed in 2010 and thereafter to assess the time-lapse imagery and to generate a numerical model of the coastal erosion process based upon all measurements.

WORK COMPLETED

Over the past year, we completed our fourth field season; we presented five talks and posters at national meetings and several at local symposia; and published three papers in peer reviewed journals. Our fieldwork in summer 2011 included servicing of our two meteorological stations; re-measuring coastal position relative to benchmarks established in 2007, 2008, and 2010; deploying Levelogger pressure transducers and hunting cameras to monitor lake shore erosion and lake levels; and continued collection of soil and lake temperature histories.

RESULTS

One of our major goals for this project was to use our time-lapse imagery to quantify the relative roles of warming surface waters and wave energy from storms in driving coastal erosion. Toward this end, we have leveraged a time-lapse sequence documenting shoreline erosion along an inland lake where we have simultaneous water temperature measurements. Since wave energy is limited in this lake environment, this record has allowed us to calibrate a model of purely thermal erosion along a permafrost coastline. Our simple model suggests that previously published models of bluff erosion predict observed erosion rates quite well.

The next step is to take these models to the Beaufort Sea coastline. The rapid retreat of the Beaufort coastline after the last appearance of sea ice – even in the absence of substantial wave energy – strongly implicates a thermal driver for the coastal erosion that we have observed (Figure 1). In the laboratory, we measured the ice content of seventeen composite samples collected from bluffs at Drew Point. Ice contents (by mass) ranged from 25-95%, with most of the samples having ice contents in excess of 50%. Combined, these data suggest that thermal processes may be more important than

mechanical processes in eroding this coastline. A corollary to this is that continued increases in sea surface temperatures could directly influence erosion rates into the future.

Thus far, we have used remotely sensed records from the MODIS satellite to reconstruct time series of sea surface temperature and to evaluate the total thermal erosion potential in this setting. Comparisons of these coarse-resolution data with observations of coastal erosion rates from repeat measurements of onshore benchmarks also indicate that thermal processes could account for the majority of erosion that we have observed over two summers of monitoring.

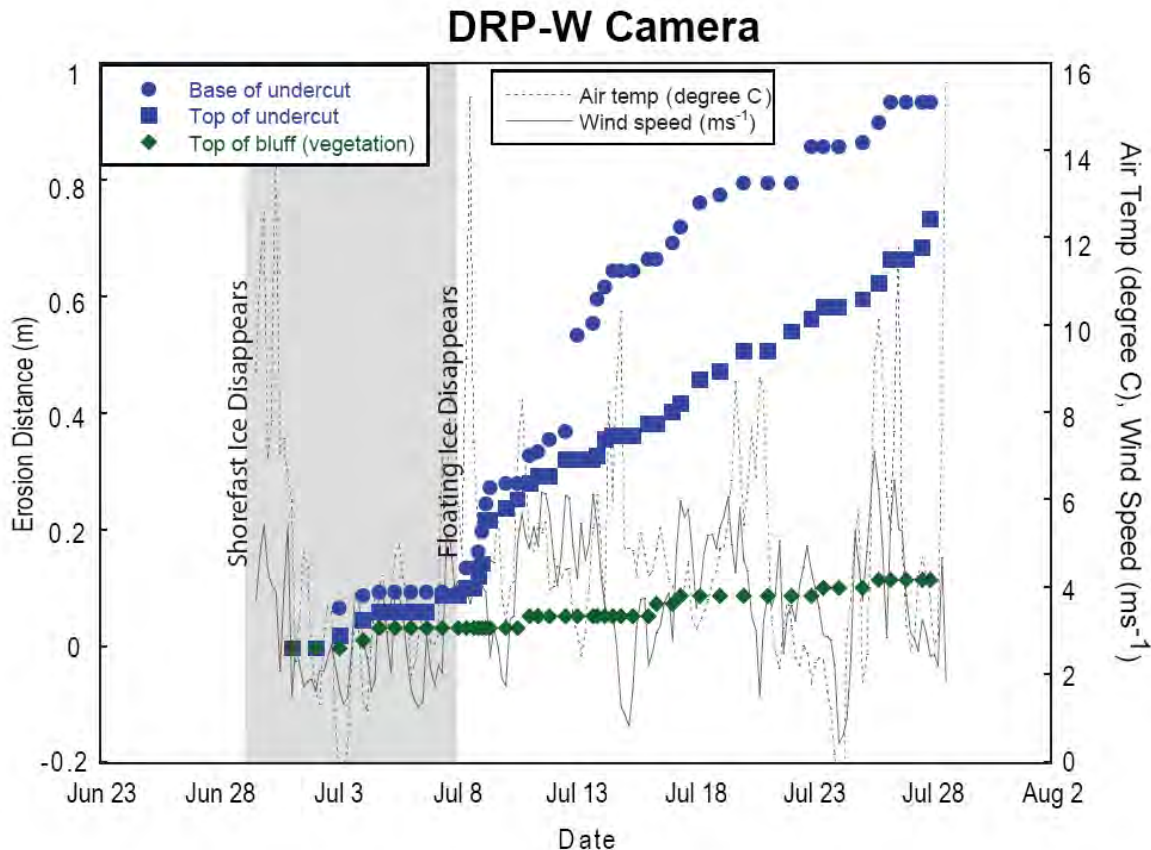


Figure 1. Rate of coastal erosion over July 2008 as reconstructed from time-lapse imagery at Drew Point. Erosion accelerates following retreat of sea ice, and is ongoing even in relatively calm wind conditions.

We used Nimbus 7-SMMR /SSM/I and DMSP SSMI Passive Microwave data to assess sea ice concentration around the Drew Point coast. This dataset runs from 1978 to the present at daily or two-daily time resolution, but has a low spatial resolution (25 by 25km gridcells).

To address whether this data is adequate in the nearshore we extensively validated the low-resolution data against more detailed operational ice charts. These charts are drawn by analysts based on satellite data from a number of instruments as well as ship-based and aerial surveys.

Whereas previous validations have been concerned with the regional ice extent, such comparisons have not focused on the near-shore zone specifically. We cross-evaluated the passive microwave SSM/I sea ice concentration in the nearshore zone of the Drew Point coast along the Beaufort Sea against high-resolution NIC operational data, and MODIS remote-sensing imagery. We focused on the 2008 open water season, the comparison confirmed the accuracy of the estimated first-day of open water based on the passive microwave data. It also told us that the window of ice retreat in the nearshore zone (4km) is within 3 days of the estimated date of break-up derived from the passive microwave instruments for the larger 25km nearshore region.

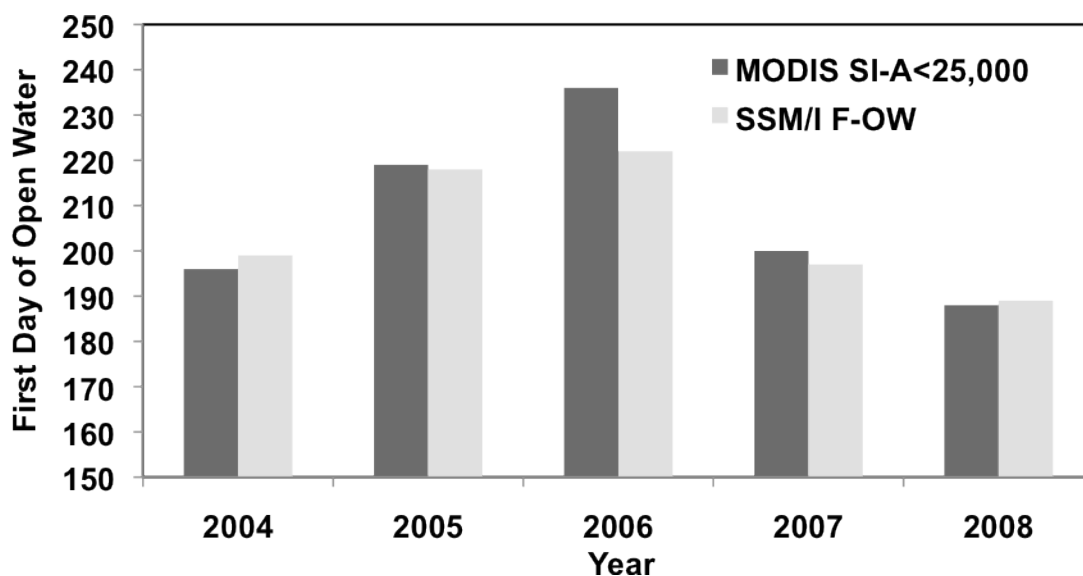


Figure 2. First-day of open water as retrieved from SSM/I signal sea ice concentration <15% corresponds with first day that sea ice area on the high-resolution MODIS imagery falls below 25,0000 km² for 2004-2008.

Consequently, cross-evaluation of sea ice concentrations retrieved from passive microwave signal (SSM/I) against high-resolution IMS data and MODIS imagery for 2004-2008, shows that the use of SSM/I in the nearshore zone of the Drew Point area along the Beaufort Sea is adequate for assessment of the longterm trends in break-up and freeze-up days.

We evaluated the effects of increased fetch on coastal erosion by wave energy. We analyzed the data to determine ‘open-water distance’, the distance from a coastal cell towards the sea ice margin where concentration rises above a wave dampening threshold (we used >50% ice). This allows us to show how fetch develops over the year and how it is related to the 20-year average fetch (Figure 4).

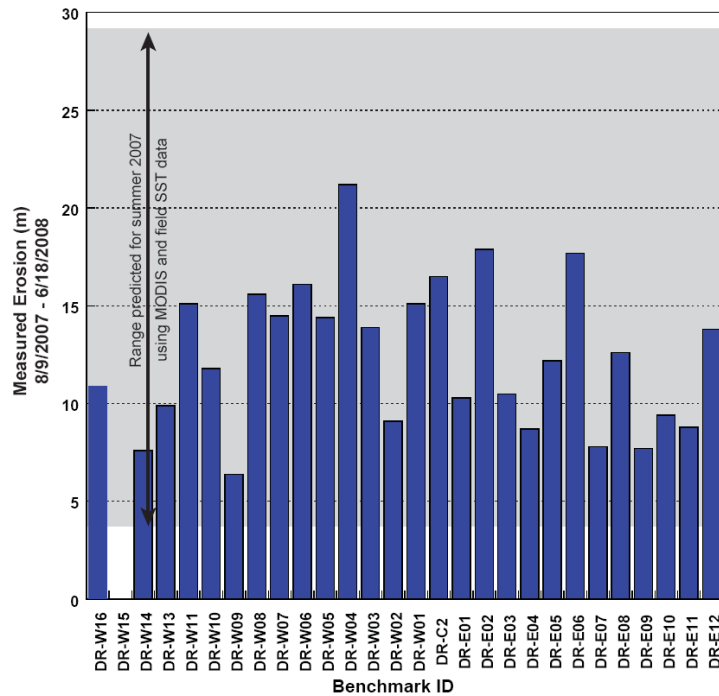


Figure 3 Integrated coastal loss over an entire season (9th of August 2007- 18th of June 2008) as reconstructed from repeat survey transect along Drew Point. Total loss is consistent with thermal erosion potential modeled from MODIS.

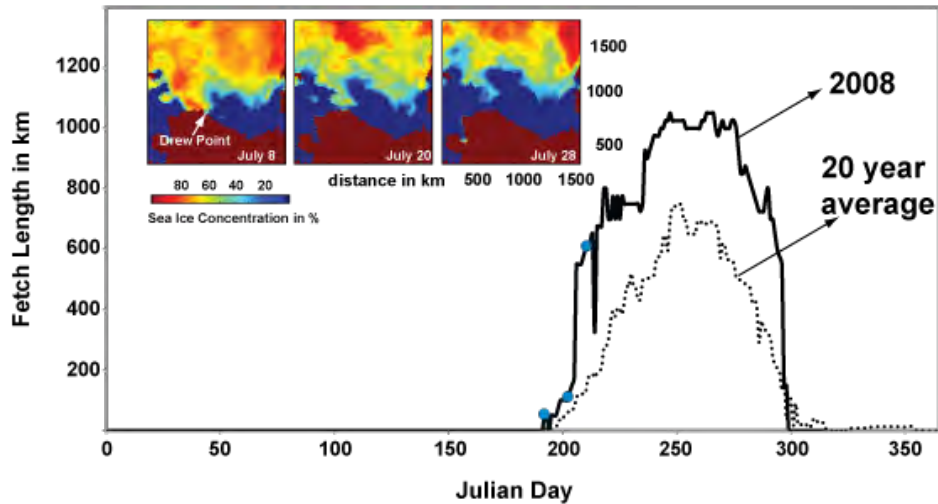


Figure 4. Fetch Length at Drew Point for different stages over the summer season 2008 is reconstructed from Nimbus-7 Passive microwave data, 2008 has open water distances that are 100's of km longer than the 20 year average conditions.

From summer 2009 wave buoy data and the thermal loggers we had deployed with these sensors, we have extracted information about the role of storms in local mixing of shelf waters. The highest ocean temperatures adjacent to the coastal bluffs occur not long after sea ice detaches from the coastline. A single storm event thoroughly mixes the shelf waters over a reach of shelf that is at least 10 km in width normal to the coastline, and they remain well mixed through the remainder of the summer except for several discrete events, all associated with storms.

We have now carefully analyzed the sea ice records from 1979 to present, as this sets the context for coastal erosion. An important result is the lengthening of the sea ice free period of the summer. We show that for our reach of coastline, the sea ice free period has lengthened considerably, resulting in roughly 2.5-fold increase in exposure to melt by seawater. This expansion of ice-free conditions is asymmetrical, with the majority of the lengthening being into the fall season (0.9 days/yr), and smaller expansion into the mid-summer (0.7 days/yr) (Figure 5). This reduces the leverage of the expansion on acceleration of coastal bluff retreat, as the sea surface temperatures in the fall are declining due to decline in direct insolation.

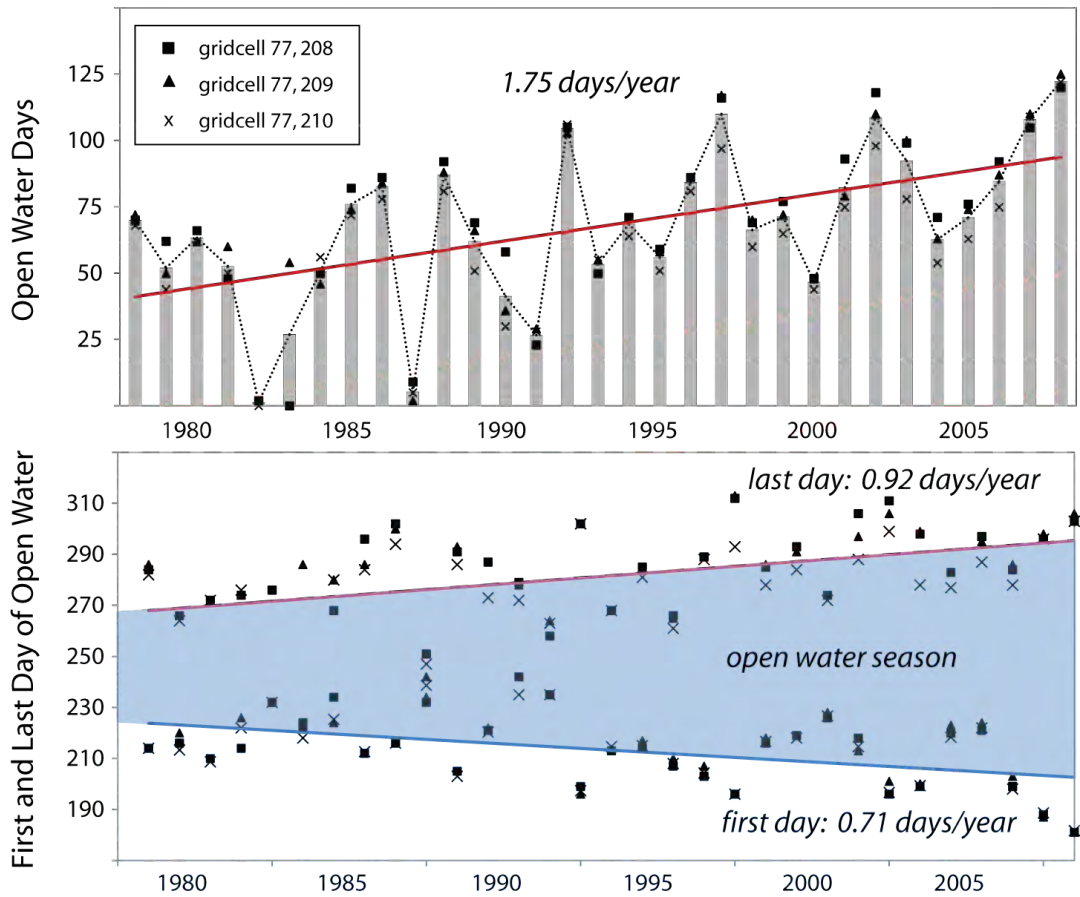


Figure 5. History of sea-ice free conditions (open water) in 3 adjacent cells along Beaufort Sea coastline, centered on our research site.

Our offshore work during the summer of 2009 gave us our first look at the detailed bathymetry in the shallow Beaufort Sea. One hypothesis to be tested is that if coastal erosion rates have in fact accelerated over the past century, there should be an inflection in the bathymetry that reflects this acceleration. There are suggestions from our bathymetric surveys that such an inflection exists in the nearshore environment which would be consistent with the idea that coastal erosion rates have accelerated in the recent past.

Summer 2010 field effort and data analysis

The summer 2010 field effort netted us time series of wave level (including contributions from waves, surge and tides), water temperature at several near-shore sites, and coastal erosion patterns from time-lapse photography. We had deployed four cameras, two high-end cameras one on land and the other attached to a pole embedded in the subsea permafrost; and two lower resolution cameras (hunting cameras) of the sort we have deployed in previous summers. We used image feature tracking analysis to quantify coastal bluff demise. The data analysis of the August 13th-Sept 11th period, the water temperatures were remarkably homogenized in the near-shore zone. Water level shows clearly the role of surge set-up in modulating the location of the water impact with the cliff face, resulting in bluff retreat and block melt rates that vary significantly on short timescales. The demise of the toppled coastal bluff blocks is revealed by the offshore camera. It is noteworthy that the pattern is best explained by our algorithms that combine SST, significant wave height and water level. This provides a validation data set for our numerical models of this process. The retreat observed in this one-month interval was of the order of 10 m, much of a year's worth of retreat according to our pin-flag measurements from the last two summers.

Summer 2011 Field Effort

From July 29th through and August 10th 2011 graduate student Katy Barnhart visited the Drew Point, Lake 31, Lake 145, and East Lake Teshekpuk field sites while working with USGS collaborators. The aim of the field season was to repeat mapping of the coast location, continue data collection of soil and lake temperatures, install two additional cameras, and install Levellogger pressure transducers to monitor water level in two lakes. Below is a brief description of the specific tasks accomplished during this field season.

At Drew Point Barnhart re-walked the full 7 km stretch of coast with a GPS, made measurements of the thermal state of the coastal bluffs, recovered soil temperature sensors deployed in Summer 2010, and re-deployed temperature sensors. At Lake 31, she assisted in maintaining the meteorological station, installed a Levellogger pressure transducer specially outfitted to survive freezing overwinter, re-measured the shoreline pinflag transect, downloaded the timelapse camera, recover temperature sensors deployed in Summer 2010 from both the lake and the soil, re-deployed temperature sensors in both the lake and the soil, made measurements of the thermal state of the lakeshore, and deployed an additional hunting camera. At Lake 145 she installed temperature sensors in the lake. At East Lake Teshekpuk, she installed another specially outfitted Levellogger pressure transducer, deployed a hunting camera, and took a near-shore bathymetric profile.

Models

The work of Masters student Nora Matell is published online with *Computers in Geosciences*. In this paper we introduce our model of the thermal impact of thaw lakes on the permafrost of the North Slope.

Graduate student Katy Barnhart has continued her work (started in 2010) on the development of numerical models of coastal bluff retreat. The physics embedded in this model includes the growth of a coastal notch by melt, toppling of the block when a torque condition is exceeded, and subsequent melting of the failed blocks. Melting is accomplished by both air and water. Water level is modulated of the water level by waves and surge and tide. Melt rate is governed by an empirically based iceberg melting algorithm that includes explicitly the roles of wave height, wave period, and water temperature.

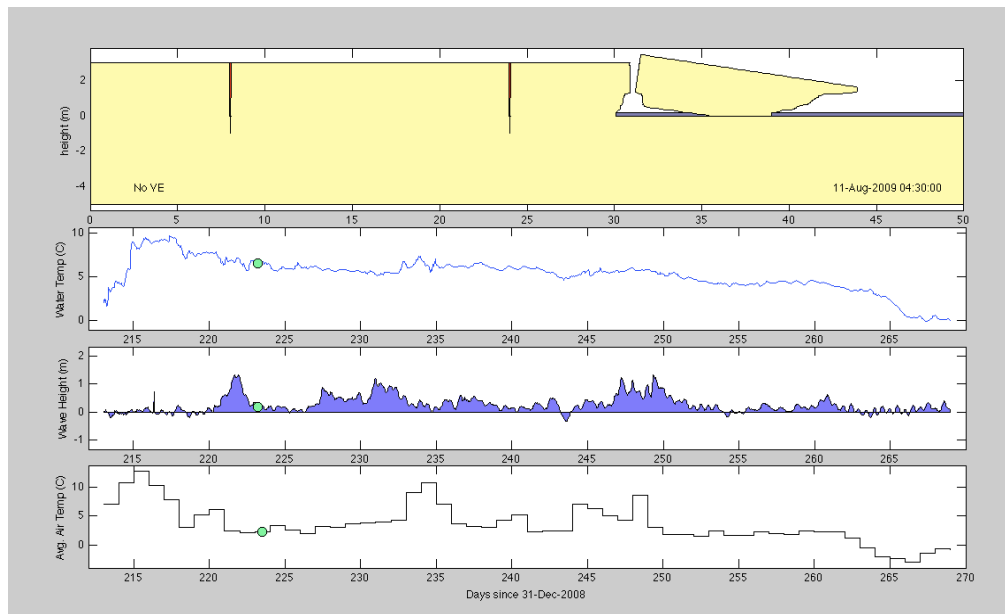


Figure 6. Screenshot of model result from coastal bluff retreat numerical model. Top: coastal bluff in cross-section, showing recently toppled bluff block. Failure occurs on ice wedges. Time series of water temperature, wave height and air temperature. Green dots display where the model is in time, JD 223.

As our goal is to place the coastal retreat problem in a quantitative, even predictive framework, we aim to exercise the model in the following ways. First we will use Summers 2009 and 2010 direct observations to refine the model to our particular coastal conditions and establish that the model can reproduce rates similar to those observed. Second, we will attempt to reproduce the rates of coastal retreat over the period for which we have both sea-ice and meteorological constraints. Finally, we will explore various climate scenarios, knowing that these must include i) expansion of sea ice free conditions, ii) models of sea surface temperature, and iii) parameterizations of sea level surge associated with storm systems.

In order to establish applicability of the erosion rules we employ, we are currently working to compare proxies for short time-scale erosion rate and the instantaneous erosion rate predicted for the same time period from our measurements of air temperature, water height, and wave characteristics (See Section on Extracting Erosion Rate Proxies From Time lapse Imagery). Our aim is not to “fit” the model to the known rates, but to demonstrate that the rules we use capture the process correctly.

In this endeavor we will mine not only the sea ice data sets, but those of on land meterological stations maintained by our USGS colleagues. As an example of the weather data now available, we display here a stack of time series of downwelling solar radiation at Drew Point, with air temperatures at the same met station. The pattern shows nicely both the solar-driven direct radiation, but variations about it that reflect both diffuse radiation and storm-driven cloud events. The air temperatures distinctly lag the insolation pattern, as the presence or absence of sea ice governs the continentality of the site (note high variation in air temperatures occurs in the time window outside the open water season in Fig 7).

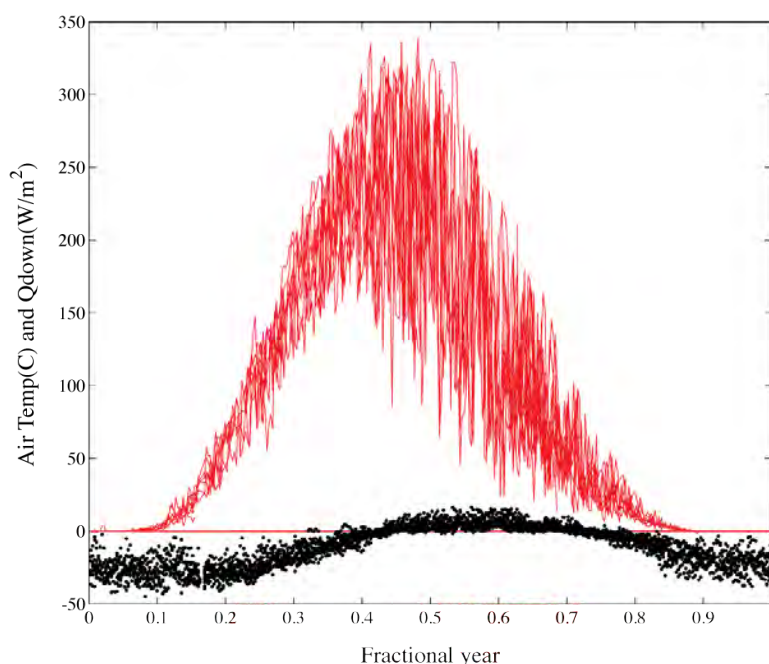


Figure 7. Stacked met records from the Drew Point met station, covering 12 years of record. Red lines = downwelling solar radiation; black dots = air temperature.

Extracting Erosion Rate Proxies From Time lapse Imagery

In order to evaluate the applicability of potential erosion rules to use in numerical modeling efforts we have developed erosion rate proxies from the time lapse imagery. Figure 8 outlines the method used to extract these proxies from the imagery collected during Summer 2010. Graduate student Katy Barnhart wrote code to automatically extract the cross sectional area of degrading blocks from the images. Barnhart worked with staff at the Extreme Ice Survey and other researchers at INSTAAR to try and develop an automatic method to detect the location of the block. However, she determined that there is little to automatically distinguish the block from the surrounding landscape in the images. In order to extract the block size, red dots must be placed on the image in order to identify the location of the block. Figure 8E shows the resulting block size history from the marine camera. Barnhart is currently

exploring the relationship between the rate of block degradation, air temperature, water temperature, and wave characteristics. and calculated erosion rates from established thermal and mechanical erosion rules. She will be presenting the results of this work at the CSDMS conference in late October 2011 and at AGU in early December 2011.

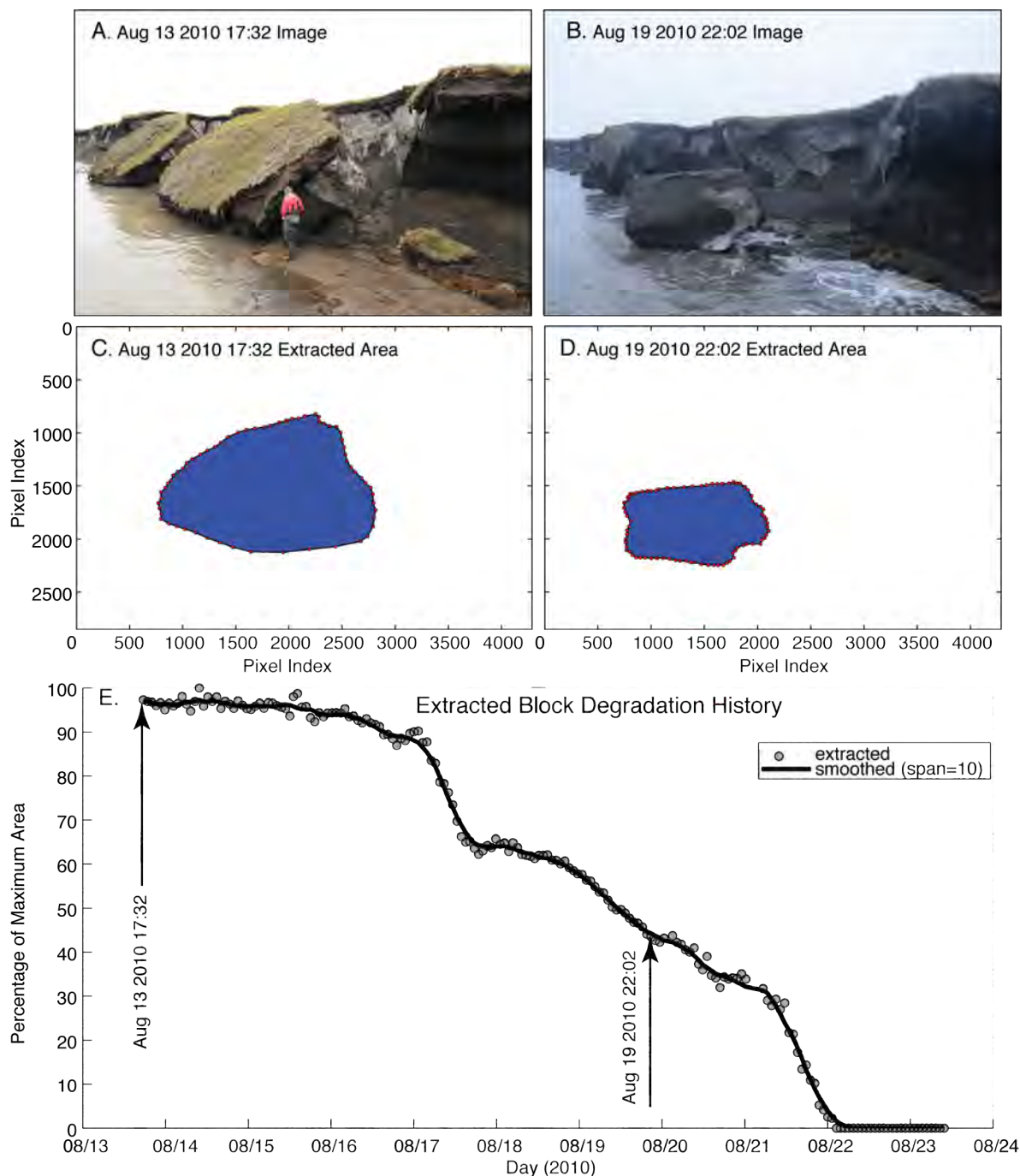


Figure 8. Overview of method used for erosion rate proxy extraction from time lapse imagery. Images A and B taken from time lapse record. Red dots are manually placed on block. Block cross sectional area is then automatically extracted from images using MATLAB (C and D). Part E shows the block size history from Summer 2010 using every 5th image (1.25 hr interval).

WRF modeling

We collaborate with Dr. Clow, USGS to further explore regional climate controls on the local meteorological and oceanographic conditions. We use the Weather Research and Forecasting Model (WRF-model) to simulate atmospheric conditions over the time periods of observation, e.g. August-September 2010 when we have a complete data record of both local meteorology, bluff retreat, sea water level fluctuation, SST and significant wave height. The WRF-model is a mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. It features multiple dynamical cores, a software architecture allowing for computational parallelism. These simulations have been set up to run in parallel on the High Performance Computing System of CSDMS.

It appears that periods of rapid erosion can coincide with relatively quiescent atmospheric conditions. We are presently correlating these simulations with water level data to explore the controlling factors on storm setup and surge.

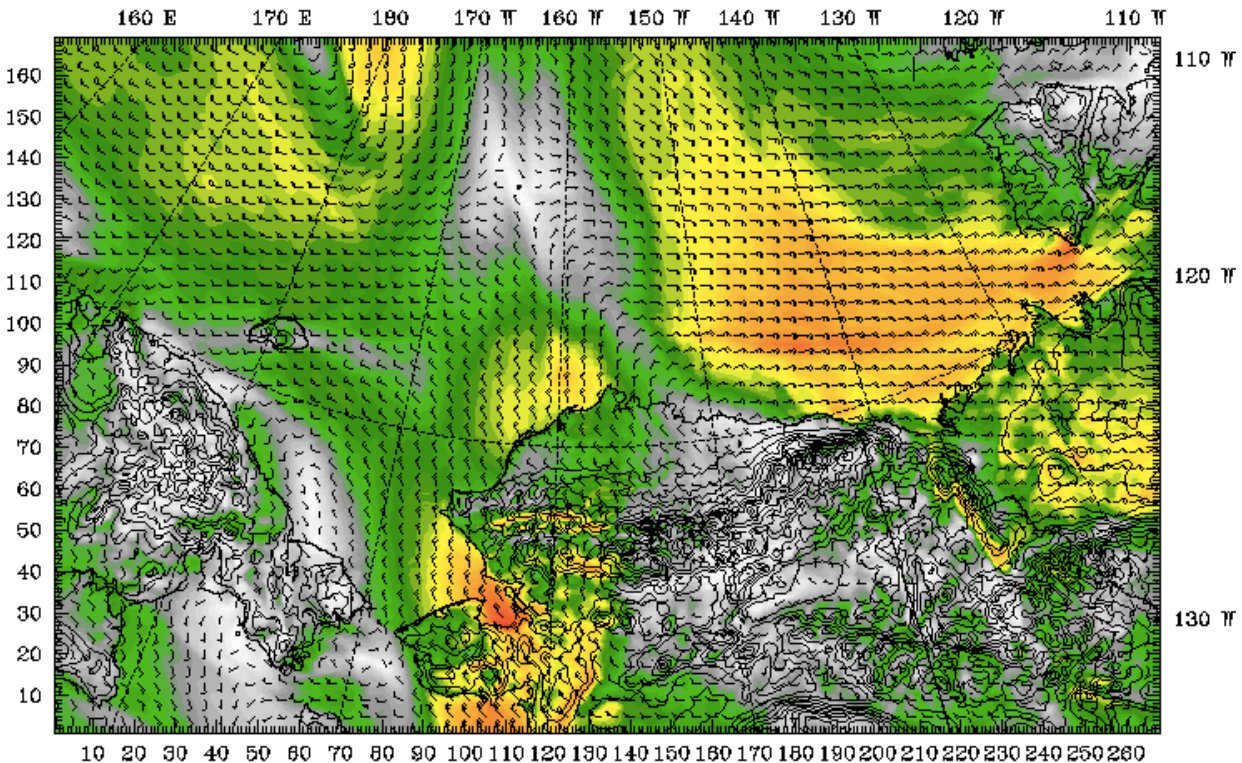


Figure 9. WRF snapshot of August 17th, 2011. Analysis of time-lapse imagery shows rapid block melt during these conditions. However the wind velocity predictions predicted with WRF are 4-8m/s along the Drew Point Coast. The storm system appears to be of modest intensity, however winds are variable and changed to a direction over the course of the day, which perhaps contributed to higher set-up.

IMPACT AND APPLICATIONS

Science Education and Communication

In Fall 2008 we produced a video from our time-lapse photography which was posted on the New York Times “Dot Earth” website. The video, entitled ‘Alaska’s Eroding Coast’, shows the dramatic loss of coastline during a period of relatively calm weather over the middle of the summer of 2007. This video has been viewed more than 36,000 times. In the summer of 2008 we participated in an IPY “Dispatches from the field” event, in which we communicated our daily science activities to a global community of science educators via satellite telephone hookup.

TRANSITIONS

Science Education and Communication

Our work has been disseminated among other researchers studying Arctic climate change and coastal processes. Our project was featured as an example on ‘Modeling Arctic Coastal Erosion’ in the policy document ‘Arctic Coasts 2009 – a Circumpolar Review’ that will be published by IASC-LOICZ-AMAP. Our coastal erosion video was also shown at the large plenary closing ceremony of the International Polar Year (IPY) in Geneva, Switzerland.

As listed in the end of this report, in FY2010 as well as FY2011 we were involved in press conferences, television and newspaper interviews, and have given several talks at both local and national venues. These interviews contributed to a feature article in ScienceNews, July 16th 2011, Collapsing Coastlines-How Arctic shores are pulled a-sea, by D. Strain.

RELATED PROJECTS

PI Anderson and co-PI Overeem are both members of the Community Surface Dynamics Modeling System (CSDMS) terrestrial working group (<http://csdms.colorado.edu/index.html>). We anticipate that our project will tap the broader expertise of the CSDMS consortium as we move into the modeling component of our study. Photos and movies of the eroding permafrost coast, as well as thawing lake shores at our field site have been added to the Educational Gallery of the CSDMS: http://csdms.colorado.edu/wiki/index.php/Coastal_GL4

The model for ‘Lake-Permafrost with Subsidence’ developed by graduate student Nora Matell has been added to the Model repository of CSDMS and is now available as open-source code for interested earth scientist worldwide. <http://csdms.colorado.edu/wiki/Model:ThawLake1D>

PIs Wobus and Anderson are both involved in an NSF-sponsored project to understand weathering in alpine environments. Thermal models of ground temperatures as well as technologies developed for monitoring weather conditions, collecting time-lapse photographs, and deploying self-contained temperature probes are creating synergies between these two projects.

NOPP Award 2010, July 2009

Our project was chosen to receive the National Oceanographic Partnership Program 2010 Award for Excellence in partnering and outreach. The award was presented to Cameron Wobus at the annual ORRAP meeting in Seward, Alaska, in July of 2010.

PUBLICATIONS

Overeem, I., R. S. Anderson, C. Wobus, G. D. Clow, F. E. Urban, N. Matell, 2011, Quantifying the Role of Sea Ice Loss on Arctic Coastal Erosion, *Geophysical Research Letters*

Wobus, C., I. Overeem, N. Matell, and R.S. Anderson, 2011, Thermal erosion of a permafrost coastline: Improving process-based models using time-lapse photography, *Arctic Alpine Antarctic Research* 43(3): 474-484. (includes cover photo of this issue)

Matell, N., R. S. Anderson, I. Overeem, C. Wobus, F. E. Urban, and G. D. Clow, Subsurface thermal structure surrounding thaw lakes of different depths in a warming climate, *Computers in Geosciences*, *in press*

Other Contributions

Overeem, I., 2010. Arctic Coastal Erosion along the Beaufort Sea. Contribution to “A Science Plan for Regional Arctic System Modeling”. In: Roberts et al., (eds.), 2010. A report by the Arctic Research Community for the National Science Foundation Office of Polar Programs.

THESES

Matell, N., 2009. Shoreline erosion and thermal impact of thaw lakes in a warming landscape, Arctic Coastal Plain, Alaska. M.Sc. thesis project, Department of Geology, University of Colorado, Boulder.

Holmes, C., 2009. “Focused Temporal and Spatial Study on Sea Ice Location in the Beaufort Sea, Alaska, and its Role in Coastal Erosion”. Honors BSc thesis. University of Colorado, Boulder.

ABSTRACTS

2008 AGU

Matell, N., R. S. Anderson, C. Wobus, I. Overeem, F. Urban, and G. Clow, 2008, "Thinking along 2 axes: Lakeshore erosion and subsurface effects of thaw lakes along Alaska's Arctic Coastal Plain", AGU Fall Meeting

Wobus, C., R.S. Anderson, I. Overeem, N. Matell, F. Urban, G. Clow, B. Jones, and C. Holmes, 2008, "Monitoring coastal erosion on the Beaufort Sea coast: Erosion process and the relative roles of thermal and wave energy". AGU Fall Meeting.

Peckham, S., Overeem, I., 2008, Sediment Transport in a Changing Arctic: River Plumes, Longshore Transport and Coastal Erosion. Arctic Change Meeting, December 10th, 2008. Quebec, Canada.

2009 AGU

Overeem was a Session chair “Arctic Coasts at Risk”, AGU Annual Meeting 2009.

Overeem, I., Wobus, C.W., Anderson, R. S., Clow, G.D., Urban, F.E., Stanton, T. P., 2009. Quantifying Sea-Ice Loss as a Driver of Arctic Coastal Erosion. AGU Fall Meeting, San Francisco, December 2009.

Wobus, C.W., Anderson, R. S., Overeem, I., Clow, G.D., Urban, F.E., 2009. Calibrating thermal erosion models along an Arctic coastline. (Invited) AGU Fall Meeting, San Francisco, December 2009.

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Anderson, R. S., Wobus, C.W., Overeem, I., Clow, G.D., Urban, F.E., Stanton, T. P., 2009. Rapid coastal erosion on the Beaufort Sea coast: A triple whammy induced by climate change (Invited), AGU Fall Meeting, San Francisco, December 2009.

2010 AGU

Barnhart, K. R., R. S. Anderson, I. Overeem, C. Wobus, G. D. Clow, F. E. Urban, and T. Stanton, 2010, Modeling the rate and style of Arctic coastal retreat along the Beaufort Sea, Alaska, Abstract, AGU Fall meeting 2010

Overeem, I., R. S. Anderson, C. Wobus, N. Matell, G. D. Clow, F. E. Urban, and T. Stanton, 2010, The impact of sea ice loss on wave dynamics and coastal erosion along the Arctic Coast, Abstract, AGU Fall meeting 2010

Wobus, C., R. S. Anderson, I. Overeem, T. Stanton, G. D. Clow, F. E. Urban, 2010, The role of summertime storms in thermoabrasion of a permafrost coast, Abstract, AGU Fall meeting 2010

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2010 State of the Arctic Conference

Wobus, C. W., R. S. Anderson, I. Overeem, G. Clow, F. Urban, and T. Stanton. Thermal erosion of an Arctic Coastline: Field observations and Model development. State of the Arctic Conference, Miami, FL, March 17, 2010.

2010 ONR Coastal Geosciences review in Chicago

Wobus, C. W., R. S. Anderson, I. Overeem, G. Clow, F. Urban, and T. Stanton. Thermal erosion of an Arctic Coastline: Field observations and Model development. 2010 ONR Coastal Geosciences review meeting, June 4 2010.

2010 Polar Society

Overeem, I., 2010, Sea Ice Loss Induces Arctic Coastal Erosion. Program and Abstracts of the American Polar Society Meeting 2010, Institute of Arctic and Alpine research (INSTAAR), Univ. of Colorado at Boulder. (Invited talk)

2010 NSIDC

Anderson, R. S., 2010, The triple whammy of sea ice loss on coastal erosion, National Snow and Ice Data Center (NSIDC), University of Colorado at Boulder.

2011 National Park Service

Anderson, R.S., July 20th 2011, webinar to the NPS titled: “Rapid erosion of a frozen Arctic coast: dominance of thermal processes and their likely acceleration along Alaska’s Beaufort Sea coast” given at local headquarters in Lakewood, CO, and broadcast nationally

2011 INSTAAR Seminar

Overeem, I., March 2011. The Impact of Sea-Ice Loss on Wave Dynamics and Coastal Erosion Along the Arctic Coast.

OUTREACH TO GENERAL PUBLIC

Bob Anderson was invited to participate in AGU Press Conference--Climate change discussion for science journalists, organized during Fall AGU 2009 Meeting. The news conference was held with a panel of 3 other Arctic scientists.

Interviews with two national papers on “Eroding Coast of Northern Alaska”. Video footage of interviews and supplementary photographic material are posted as well.

University of Colorado Press Announcement in December 2009 resulted in publications in Science Daily, Alaskan News Reader, Hindu Times.

Interview in May 2010, contributed photos to article for Anchore Press: “A fragile past - Archaeologists are scrambling as accelerated erosion sweeps away artifacts on Alaska's Arctic coast”

Overeem gave an interview to be used in a documentary about “Climate Change and its Impacts”. The working title of the documentary is 7th Generation.

Overeem contributed to a feature article in ScienceNews, July 16th 2011, Collapsing Coastlines-How Arctic shores are pulled a-sea, by D. Strain.

Data sharing

Our USGS collaborators Frank Urban and Gary Clow are sharing the data streams from our met stations on the North Slope through the Climate and Permafrost Network.

<http://data.usgs.gov/climateMonitoring/region/show?region=alaska>